Thomas Orbach
Christa Liedtke

Eco-Management Accounting in Germany

Concepts and practical Implementation

Final Report for the Project
„Management Accounting and Environmental Management: Towards the Sustainable Enterprise“

A Study of Operational and Material Flow Analysis, particulary as it is practised in Germany and how it might be used as a Part of Management Accounting

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Dipl.-Kfm. Thomas Orbach
Phone: ++49-(0)202-2492-130
Fax: ++49-(0)202-2492-138
Email: Thomas.Orbach@wupperinst.org

Dr. Christa Liedtke
Phone: ++49-(0)202-2492-130
Fax: ++49-(0)202-2492-138
Email: Christa.Liedtke@wupperinst.org

Wuppertal Institute for Climate, Environment and Energy
Division for Material Flows and Structural Change
Döppersberg 19
D-42103 Wuppertal

TABLE OF CONTENTS

1 Introduction

1.1 General Framework

Since the United Nations Conference on Environment and Development held 1992 in Rio de Janeiro, a lot of research work has been done in order to define sustainability and to set up general goals to reach a sustainable development. Today's challenge consists of the translation of general sustainability goals into concrete concepts at the macro, meso and micro level.

To realise sustainability at the company level, decision-makers need sufficient information to assess their position on the path to sustainability. Therefore, concepts have to be developed which offer a methodological framework, instruments and measures to operationalise the normative concept of sustainable development. Within this context, eco-management accounting is a tool which provides both economic and ecological information at the company level in order to support internal decision-making and control activities. However, environmental information becomes more important not only to support internal decision-making, but moreover it is crucial for companies that want to communicate with their stakeholders. Thus, the project „Management accounting and environmental management: towards the sustainable enterprise" (Eco-Count) supported by the "Nederlandse Organisatie voor Wetenschappelijk Onderzoek" (NWO) copes with the question what the implications of environmental management for management accounting and external reporting are.

Within this project, this paper deals with concepts of eco-management accounting and their implementation in Germany. For this purpose, general demands on eco-management accounting systems are formulated from a conceptual and practical perspective. On this basis, existing concepts of eco-management accounting, as they have been developed in Germany in the past 20 years, are described and critically revised. As the last part of this paper, the concept of Resource-Efficiency Accounting (REA) is presented. This concept has recently been developed by the „Sustainable Enterprise Program" of the Wuppertal Institute. REA tries to provide a simple, flexible and decision-making orientated information tool which combines an ecological sustainability indicator (material intensity) with decision-making orientated economic indicators (e.g. costs, contribution margin, profit) within a Resource-Efficiency-Portfolios. The objective of REA is to reveal saving potentials throughout the whole life-cycle and to assess economic and ecological aspects of companies' activities at different company levels.

1.2 Definitions

In international environmental science a lot of terms and expressions are used which may be equivalent but also contradictory. The following definitions are given as they are used in this paper (ERASMUS STUDIECENTRUM VOOR MILIEUKUNDE 1997; BMU/UBA 1995).

Management accounting (or internal accounting) is a system that collects, classifies, summarises, analyses, and reports information to managers to support their internal decision-making and control activities. It is defined as the identification, measurement, accumulation,

analysis, preparation and communication of information that helps executives in fulfilling organisational objectives.

Cost accounting accounts for the past, present and future costs of a product, service or operation. It establishes budgets, standard costs and actual costs.

Eco-management accounting is defined as the generation, analysis and use of financial and related non-financial information in order to integrate corporate environmental and economic policies and build a sustainable business. It is an emerging area which is of great importance to all companies which take their ecological environment seriously and wish to fully integrate environmental concerns into their business. It can be seen as a decision-making orientated company information instrument that considers simultaneously and life-cycle-wide both economic and ecological data.

Environmental management is the business of defining and achieving environmental objectives at the company level.

Input/Output Analysis is a tool to assess the ecological relevance of products, processes, services or infrastructures by analysing the inputs and/or outputs to the system studied. Examples for input/output analysis are LCA, Ökobilanz, Produktlinienanalyse or the MIPS-concept. Input/output analysis aims at reporting environmental data to management (strategic or operative) about the actual situation. Input/output analysis may be used to set up environmental management targets or strategies for action. This term might be confused with „company input/output analysis“. A company input/output analysis is an information instrument to record relevant material and energy flows of a company within a certain period of time in a structured and reproducible way.

The **MIPS-concept** is an ecological indicator developed by the Wuppertal Institute. MIPS is input-orientated, i.e. the whole material input into a system is recorded. MIPS can be used as an indicator as being part of environmental management accounting. MIPS is the basis of the ecological dimension of Resource-Efficiency Accounting (REA). MIPS and REA are described below in more detail.

1.3 Reasons why companies cope with environmental issues

A lot of efforts have been made in the past years in order to fight against harmful substances. Nevertheless, the environment is still deteriorating. The greenhouse-effect, the depletion of the ozone-layer or scarcities in clean drinking water and fertile soils are striking problems today (only to mention a few), so that environmental issues will become more and more important in the future – for companies as well. But companies suffer a lack of suitable methods and instruments to evaluate and assess simultaneously both ecological and economic consequences of their activities. Such an information tool is important for companies because of the following five reasons:

1.) Increasing costs for environmental protection measures
The costs for environmental measures (end-of-pipe technologies) were four times higher in 1992 than they were in 1975. In the past years, these costs decreased slightly because of the

increasing importance of integrated technologies (STATISTISCHES BUNDESAMT 1996). But costs of integrated technologies can only be partly, or even not at all, allocated to environmental measures so that organisations can hardly assess their total costs of environmental measures (hidden costs). These costs have to become transparent with the aid of suitable accounting systems.

2.) Potential of cost reduction by environmental management
The rising pressure of the world market makes companies try to decrease their costs even in fields where no cost reduction potential has been considered before. This includes material and energy savings. The equation „environmental protection = higher costs" has been proved to be at least partly wrong by numerous practical examples (GEGE 1997; WEIZSÄCKER ET AL. 1995; KUNERT AG ET AL. 1995). Thus, companies are looking for information systems that help to explore systematically cost reduction potentials.

3.) Anticipation of future development
It might be possible that conditions of the economy will change in the future (e.g. by material and energy taxes). The environmental policy of several governments (like the Dutch one, NEPP 1993) has as an objective the dematerialisation of the economy (BMU 1998). To avoid higher costs, companies need suitable management accounting and controlling tools.

4.) *Legal regulations*
Especially in Germany, there are several current legal regulation which force companies to consider environmental aspects. The *Kreislaufwirtschafts- und Abfallgesetz* (law on recycling and waste) oblige companies to avoid waste and to generate input/output analysis in some cases. The *Umwelthaftungsgesetz* (environmental liability law) and the *Produkthaftungsgesetz*[1] (product liability law) underline the company's responsibility throughout the whole product life-cycle. To be in compliance with these new laws and to minimise risks of claims, companies are well advised to implement material flow management and life-cycle management.

5.) *Demands of stakeholders*
Last but not least, companies are confronted with increasing demands by their stakeholders. Employees, stockholders, neighbours, etc. want to be informed about the company's environmental performance. Furthermore, environmental soundness becomes more and more a convincing argument to be put to the client. The efficient generation of environmental performance data demands a suitable information system.

1.4 Demands on Eco-Management Accounting Systems

For 20 years research has been trying to link economic cost information with ecological information. The development of this interlinkage is the main task of eco-management accounting. Such an information system has to fulfil the following theoretical and practical

[1] The *Produkthaftungsgesetz* is not an environmental law, but it norms the producer's responsibility throughout the whole life-cycle of products.

demands to be suitable for serving as an instrument for making economically and ecologically sound decisions. Such a system must (LIEDTKE ET AL. 1997):

- consider ecological aspects to enable management to assess the ecological consequences of its decisions. Ecological aspects should be expressed by a flexible set of indicators. These indicators have to be simple, reproducible and they must show general tendencies to serve as a basis for the company's decisions.
- consider economic aspects. Ecological information alone cannot lead to sustainability in companies. The simultaneous consideration of both ecological and economic information allows a holistic view of the consequences of the company's decisions. Information about the increase in efficiency is incomplete if it does not contain the development of costs at the same time.
- consider the whole life cycle. This demand is fulfilled by costs as they already include the whole added value. This is not the case for ecological aspects. The consideration of the whole life-cycle from an ecological point of view avoids sub-optimum solutions which increase the company's environmental situation by decreasing it at another stage of the life-cycle (e.g. during raw material acquisition).
- rely on existing data in the company, as data collection is a very cost and labour intensive procedure.
- generate reliable and reproducible information allowing less subjective influence possible.
- generate data which is relevant for decisions.
- be flexible enough to be used on the basis of different cost accounting systems.

2 State of the Art in Eco-Management Accounting

The increasing importance of considering environmental aspects within company's decisions demands a broader scope in management accounting. Eco-management accounting should enable management to integrate environmental issues into the decision-making procedure. This chapter deals with the state of the art of eco-management accounting. In the past a number of concepts of eco-management accounting have been developed and have been more or less successfully implemented in companies. These concepts have improved the transparency of "environmental costs" and they have induced a lot of activities to improve the environmental situation of companies. These concepts can be classified into four approaches, which differ according to their system boundaries (see table 1):

- Narrow economic approach
- Extended economic approach
- Narrow ecological approach
- Integrated economic and ecological approach

Table 1: Overview of concepts of eco-management accounting (ORBACH ET AL. 1998)

Approach	Economic System boundary	Ecological System boundary	Concepts of Eco-management accounting (Examples)
Narrow economic approach	limited to the company	not considered	• *Kostenermittlung der Emissionsminderung nach VDI 3800* (Cost Recording according to the VDI-Guideline 3800) • *Ermittlung der Umweltschutzkosten auf Vollkostenbasis* (Environmental Cost Recording based on Absorption Costing)
Extended economic approach	Company, in some cases the whole economy	not considered	• *Ökologische Kostenrechnung* (Ecological Cost Accounting) • Full Cost Accounting
Narrow ecological approach	not considered	Company, in some cases the whole product line	• *Ökologische Buchhaltung* (Ecological Bookkeeping) • *Instrumente des betrieblichen Umweltschutzes* (Instruments of Company Environmental Protection)
Integrated economic and ecological approach	limited to the company	limited to the company	• *Reststoffkostenrechnung* (Waste Cost Accounting) • *Stoff- und energieflußorientierte Kostenrechnung* (Flow Cost Accounting)
System-wide economic and ecological approach (ch. 3)	costs or other economic dimensions relevant for decision-making	life-cycle-wide consideration	• *Ressourceneffizienz-Rechnung* (Resource-Efficiency Accounting)

The existing concepts could also be classified according to the different cost accounting systems they are based on. However, several concepts are flexible in implementation and can be applied to different cost accounting systems. Moreover, the objective of eco-management accounting is to reveal (hidden) environmental costs and to explore potentials for environmentally sound cost reduction, which could be obtained by different cost accounting methods (BMU/UBA 1996), so that this classification will not be applied. Table 1 gives an overview of the concepts presented in this chapter and their system boundaries. This table does not show all existing concepts. Two concepts of each approach have been chosen.

In this table, the original German terms of the concepts presented are given in *italics*, the English translation is given in (brackets). In the following sections, only the original „German terms" of the concepts are used.

2.1 Narrow Economic Approach

The first approach is limited to cost recording of environmental protection devices in order to make them transparent. Ecological consequences of decisions are not considered.

An example of this approach is the „*Kostenermittlung der Emissionsminderung*" according to VDI-Guideline 3800. Within this concept, all costs are revealed that are caused by measures in order to reduce, avoid and control emissions including product orientated measures. The aim is to identify all costs in order to comply to the Bundes-Immissionsschutzgesetz (BImSchG) and to compare costs of different environmental protection measures (VDI 1979). No information is given concerning the extent of emission reduction.

The *„Ermittlung der Umweltschutzkosten auf Vollkostenbasis"* has the same objective but aims at the product level. All costs in the context of environmental protection are allocated to narrow or mixed environmental cost centres within a conventional absorption costing procedure. As it is difficult to separate those environmental costs occurring at installations which serve other tasks than environmental protection, too, this concept records mainly end-of-pipe costs. These costs are referred to units of output by cost centre and unit of output accounting. This concept can be used to show the share of environmental costs in the product price (HAASIS 1992).

2.2 Extended Economic Approach

These concepts are limited to the consideration of environmental costs, too. But unlike the concepts of the narrow economic approach, they try to include so-called external costs in the cost accounting system. External costs are defined differently within the different concepts. The economic system boundary is enlarged to outside the company.

A first example is the *„Ökologieorientierte Kostenrechnung"*. This concept defines external costs as „costs of environmental burdens of the company's activities, which have not yet been internalised, i.e. costs of the impacts which have not yet been avoided, reduced, or removed" (ROTH 1992). Relevant environmental burdens in this concept are impacts that are submitted to legal threshold values.

A concept with a broader scope is „Full Cost Accounting“ (not to be confused with the German term *„Vollkostenrechnung“*), which has been implemented at Ontario Hydro, a Canadian energy producer. There, external costs are all costs of damage resulting from the company's activities, and borne today by the whole economy. The long-term objective of this internalisation of external costs is to consider external effects within planning and decision-making. Full Cost Accounting is based on five effect categories (mortality, morbidity, cancer cases, crops and building materials) which are caused by different „Pollutants of Concern“ and assessed by „Unit Values“ (EPA 1996).

It has to be mentioned that the choice of the effect categories is subjective and a monetary assessment of external effects is scientifically controversial. Ontario Hydro points out that Full Cost Accounting is not the main decision-making instrument but one of several of the company’s information and assessment instruments (FICHTER ET AL. 1997). It is not used for external communication and for pricing.

2.3 Narrow Ecological Approach

The third approach only considers material and thus ecological effects of the company’s activities. This approach is focused on non-financial information about energy and material flows. As eco-management accounting should link ecological and economic information, this approach is first of all part of environmental accounting (*Umwelt-Controlling*). Nevertheless, the concepts are mentioned on account of completeness.

The concept of *„Ökologische Buchführung“* assesses ecological scarcities with the aid of eco-factors (BMU/UBA, 1995). They are calculated based on the impacts in a defined geographical region referred to maximum tolerable burdens (e.g. legal threshold values). All instruments of a company’s environmental protection can be allocated to this approach, too, such as *Ökobilanz* (eco-balance), LCA, *Produktlinienanalyse* (product-line analysis) and Material Intensity Analysis. These methods try to assess life-cycle-wide inputs and/or outputs of products or whole product lines in order to show priorities for action.

2.4 Integrated Economic and Ecological Approach

These concepts are characterised by their intent to consider simultaneously economic and ecological aspects. They focus on parameters that can be influenced by the company itself, such as waste, material and energy flows, or material inputs in the production.

The concept of *„Reststoffkostenrechnung“* defines environmental costs as expenses which will not occur if the company no longer generates waste (FISCHER 1995). These are all costs linked to solid wastes, residual waters, and exhaust gases. The concept tries to allocate costs correctly to waste materials or to desired products in order to detect cost reduction potentials linked to waste reduction. This method is based on the assumption that a company has to pay three times for waste (FISCHER 1997): when buying materials becoming waste later on, while producing waste and for disposing waste. Experience has shown that the costs for purchasing materials becoming waste are much higher than for their deposition. This result could not be found by traditional cost accounting.

The concept of *„Stoff- und energieflußorientierte Kostenrechnung“* (also called *„Flußkosten-rechnung“*) focuses on material and energy flows, too. But this concept does not distinguish between environmental and non-environmental costs (FICHTER ET AL. 1997). It relies on the hypothesis that *all* environmental impacts are linked to material and energy flows while the *„Reststoffkosten“*-concept only focuses on wastes. “Flow costs“ within this concept are defined as costs of goods and services which are linked to the company’s material and energy flows. This definition includes input costs (e.g. purchasing), transformation costs (e.g. transport costs and production costs) as well as output costs (e.g. deposition of wastes). Flow costs are calculated by a horizontal summation of all costs accruing along the way through the company (from input to output). Thus, this concept links the company’s material flow management with cost accounting and enables an integrated consideration of economic and ecological aspects. The objective is to explore all costs of the company’s material and energy flows in order to detect cost driving factors.

2.5 Critical Review of Existing Concepts

The development of the different concepts of eco-management accounting is significant for the development of environmental protection in general: the shift from end-of-pipe technologies towards integrated technologies and the reduction of material flows. During the 70s and 80s, the main approach of environmental policy was to solve environmental problems by filtering and treating harmful substances. Accounting instruments have been developed in order to explore the costs occurring for filter and treatment technologies, like the *VDI-Richtlinie 3800*. Nowadays, after the first cleaning-up steps have been done, it becomes evident that environmental protection can be realised more cheaply and effectively by integrated technologies aimed at avoiding or at least reducing harmful substances and by the reduction of material flows. Thus, eco-management accounting aims today at revealing reduction potentials of the company's material and energy flows in order to reduce simultaneously environmental impacts and costs. For this purpose the integrated concepts of eco-management accounting have been developed.

The narrow economic approach relies on a recording of costs for end-of-pipe solutions for the sake of keeping record. It is not suitable to support decision-making as it treats past data without considering ecological consequences. Furthermore, this approach implies that environmental protection is automatically linked with higher costs so that cost reduction potentials by material flow management cannot be explored with the aid of these concepts.

The extended economic approach relies on the hypothesis that product prices do not tell „the ecological truth“, i.e. costs of environmental impacts of products are not included in their price. If it was possible to internalise these external costs into cost accounting and product pricing, the company would only have to optimise their cost situation to reduce simultaneously their impacts on the environment. Furthermore, environmentally problematic goods then become more expensive in comparison with more environmentally sound alternatives, so that the market would favour "green products". But this internalisation is confronted with several methodological problems (HINTERBERGER ET AL. 1996). Firstly, it is impossible to predict all possible effects of environmental impacts resulting from human's activities due to the complexity of eco-systems. To monetarily assess known impacts today's

and future scarcities on both the input-side and the output-side have to be known to their entire extent. But from a today's point of view this is not possible. Last but not least, by defining a price for every environmental good, it would be possible to „set two trees off against 200 turkeys“, which does not represent the real interrelations of complex eco-systems. Thus, information obtained by the internalisation of external costs can be incomplete with regard to these methodological problems or even wrong, if impacts are not yet considered to be harmful.

The narrow ecological approach does not link environmental data with economic data. Thus, this approach cannot serve as a basis for management in decision-making. Strategies of action or optimisation based only on this approach could, in the worst case, endanger the economic success of a company.

Taking into account the criticism above, integrated economic and ecological concepts focus on the real cause of environmental problems: the material and energy flows (SCHMIDT-BLEEK 1994). Thus, they focus on parameters that can be influenced by the company itself. With the aid of these concepts, it becomes possible to realise cost reduction by dematerialising the company's activities (DEY 1997). Referring to the three theoretical demands on eco-management accounting, the concept of *„Flußrechnung“* is best suited (SCHALTEGGER ET AL. 1996). Nevertheless, it does not reflect the „ecological history and future“ of material flows. It only relies on company's internal material flows without taking into account down- and upstream material flows induced outside the company by its activities. The concept does not allow a life-cycle-wide consideration of ecological aspects.

2.6 Practice of Eco-Management Accounting in Germany

The degree of implementation of eco-management accounting varies largely in Germany (ERASMUS STUDIECENTRUM VOOR MILIEUKUNDE, 1997) and in Europe (BOUMA; WOLTERS, 1998). A representative survey among 513 German companies showed that in 1991 only 18.6% of them had carried out eco-management accounting (COENENBERG ET AL. 1994). However, the survey does not give information about the type and extent of the eco-management accounting system. It has been shown in this chapter that the different concepts vary largely according to the scope and the methodology, so that the survey can only give a first overview.

Concepts of the narrow economic approach are implemented in companies that are obliged by law to give information about costs of environmental protection devices. This data is published by the German Federal Statistical Office (Statistisches Bundesamt) every four years (STATISTISCHES BUNDESAMT 1996). This census is carried out by all electricity, gas and heat producing companies, about 3.000 companies supplying water and 68.000 mining and production companies. The costs of environmental protection devices are calculated within an extra accounting procedure, so that the company's cost accounting system is not concerned. Moreover, neither costs of integrated technologies nor operating costs are recorded due to problems in separating environmental costs from other costs.

The same is true for companies with high costs for environmental protection (e.g. oil industry, chemical industry). As these costs can rise up to 20% of the turnover, these companies want to be informed about the extent of their environmental costs. The degree of detail depends on several factors, such as for example the amount of environmental costs, the cost accounting system, qualification of employees, etc. But here again, the company's cost accounting system is not concerned (GRESSLY 1996).

More sophisticated concepts of eco-management accounting are only implemented in very few companies according to the information given by German experts[2]. Concepts of the extended economic approach are part of the company information system in a few American companies (e.g. Amoco Oil, Ontario Hydro), however, they are not practised in Germany to a considerable extent. Integrated economic and ecological concepts have been implemented in some German companies in initial projects (e.g. Kunert AG), but a full integration into the cost accounting system and into the day-to-day decision-making process is still missing (FICHTER ET AL. 1997). Presently, several German research institutes are carrying out projects in this field with companies of different sectors aiming at introducing *Reststoffkostenrechnung* or *Flußkostenrechnung*.

The degree of implementation of eco-management accounting is linked to the size of companies in different ways. Bigger organisations often have experience with ISO 9 000, TQM and ISO 14 000 what can facilitate the implementation of eco-management accounting. Another advantage is that big organisations normally have a rather sophisticated and efficient company information system where data on material flows can easily be derived from. And last but not least, bigger organisations have the financial and human capacities to introduce eco-management accounting. On the other hand, smaller companies often do not see the interest of implementing environmental management or eco-management accounting systems due to several reasons. But if an important person of the company (i.e. the general manager) does have the willingness to implement such a system, new ideas will be realised and advanced very ambitiously (see the example of KAMBIUM in the annex). The general manager is then the driving force. Moreover, smaller organisation have more flexible structures which is favourable if, for example, additional data is needed.

[2] This statement has been given by several experts during interviews in October 1998. It reflects as well the experience of the Sustainable Enterprise Team of the Wuppertal Institute.

3 Resource-Efficiency Accounting

Regarding the criticism on existing eco-management accounting systems, the Sustainable Enterprise Program of the Wuppertal Institute has developed the concept of Resource-Efficiency Accounting (REA). In this concept, not only material is considered as a resource but also money: both have to be used efficiently in order to guarantee the sustainable success of a company (ORBACH ET AL. 1998). The core thesis of Resource-Efficiency Accounting is:

> Only if economic and ecological aspects are considered simultaneously and life-cycle-wide, can all cost reduction potentials of a company be explored. These cost reductions are ecologically sound.

3.1 Conceptional Background of Resource-Efficiency Accounting (REA)

The methodology of REA is based on an economic and an ecological dimension which are combined within Resource-Efficiency-Portfolios. That means, that REA does not express environmental effects in monetary units. The economic dimension relies on data derived from the company's cost accounting system. As there are no standards for cost accounting, REA can be integrated into different systems (absorption costing, direct costing, activity based costing). The aim is to reveal hidden costs, i.e. costs which have not been allocated to the cost centre or the product that caused these costs. The transparency of company material flows within REA can be used to modify existing cost allocation procedures.

The ecological dimension of REA is based on the MIPS-concept, which has been developed by FRIEDRICH SCHMIDT-BLEEK at the Wuppertal Institute. The MIPS-concept is based on the internationally agreed assumption that life-cycle-wide inputs of primary materials can be used to indicate the general environmental impact potential of products and services. An increasing material input will generally indicate a rising pressure and a decreasing input will reflect a falling pressure on the environment (SCHMIDT-BLEEK 1994).

The MIPS-concept has been developed with regard to methodological and practical problems in implementing output-orientated assessment approaches such as LCA, *Ökobilanz* (eco-balance) and *Produktlinienanalyse* (product-line analysis) (SCHMIDT-BLEEK 1994):

- It is doubtful whether it will ever be possible to evaluate or even to know all possible impacts of human action. This would presuppose that man can control nature and that the behaviour and reaction of eco-systems are predictable. This is not (yet) the case.

- An output approach is not fully compatible with the precautionary principle. In the past impacts have been discovered as harmful after having caused serious and often irreversible damage to the eco-system (e.g. CFC-problem). At best output-orientated methods can only inventory already existing damage to the eco-system.

- Output-orientation favours "end-of-pipe technologies". These technologies have been the main issue in the successful fight against toxic substances and emissions during the last

twenty years. However, a high price had to be paid for filters, catalysts, purification plants, etc. Nowadays it has become commonly recognised that it is more efficient to fight against harmful substances by avoiding them or at least by applying integrated technologies. This is particularly relevant in the case of CO_2 and the related reduction of fossil fuel use.

It has become clear in recent years that an efficient ecological policy demands more than the combating of harmful substances. Such a policy demands furthermore a multi-issue approach, where dematerialisation plays a major role. To redirect the economy of the industrialised countries back onto "a sustainable path", the enormous quantities of materials that are moved in order to provide those persons living in industrialised countries with their prosperity, should be reduced by a factor of 10 (SCHMIDT-BLEEK 1998). This aim can only be achieved by an input-orientation of ecological policy and its instruments. It has to be ensured that less material enters the technosphere as it represents a potential impact on the environment.

Schmidt-Bleek suggests comparing products, services and infrastructure on the basis of their life-cycle-wide material input per service-unit using a measure called **M**aterial **I**ntensity **p**er **S**ervice-Unit (MIPS). The service-unit as the functional unit ensures the comparability of different products (in the following the expression "product" includes services and infrastructure as well) delivering the same service.

The calculation of material intensity is done within the framework of a **Ma**terial **I**ntensity **A**nalysis (MAIA). There, all inputs of raw material and resources of the product being studied are added up. Raw materials in the sense of MAIA comprises all materials (incl. energy carriers) moved by man from natural sites by technological means. The total material input represents the sum of all life-cycle stages (such as raw material extraction, pre-production, transport, etc.), use and recycling/waste disposal. The measure is a mass unit (kg or t). The total material input minus the proper weight of the product indicates the ecological rucksack representing the mass of all material taken from or moved in the environment to produce the product without, however, being part of the product itself. Referring the material input to a service unit or a specific quantity leads to the material intensity. The material intensity of 1 t of steel, for instance, amounts to 7 t/t. Hence this results in an ecological rucksack of 6 t/t.

The MIPS-approach has several advantages by referring to the life-cycle-wide material inputs (HINTERBERGER; WELFENS 1996):

- It is stated that environmental impacts cannot be assessed to their entire extent and in all detail. Eco-systems are too complex for doing so. But it is possible to compute general tendencies. MIPS is a screening tool for an ecological assessment.

- Input data already exists in companies and/or is easier to record than output data. Thus, the MIPS-concept is easy to implement in companies. For special purposes it is possible to generate output indicators.

- The common basis for the assessment is the mass unit (kg or t), which avoids the methodological problems of LCA during the evaluation and assessment procedure. Today, it is not possible to aggregate the different categories of LCA on a scientific basis.

- The results of MIPS are reproducible and show general tendencies. The MIPS-concept relies on a strict methodology, which leaves only very little room for subjective influence.

- The MIPS-concept considers the whole life-cycle of products expressed by the ecological rucksack.

- MIPS is a suitable measure to promote environmental efforts of a company as it is simple, comprehensible and striking. The ecological impact potential of a product could be given, for example, by labelling it with an ecological rucksack.

The Division of Material Flows and Structural Change of the Wuppertal Institute has calculated the material intensity of the most important materials and of a lot of products. The results are published in the Internet (http://www.wupperinst.org).

3.2 Use at Company Level: Company Input-Output Analysis

A first step of REA aims at recording company-wide material inputs and outputs (top-down approach). During this step, the company itself is considered as a black box: all material and energy flows are recorded and listed on a company input/output balance sheet (see table 2) without assessing them (LIEDTKE ET AL. 1995).

Table 2: Structure of a company input/output balance sheet (LIEDTKE ET AL. 1995)

I.	Input
I.1	Raw materials
I.2	Energy
I.3	Water
I.4	Air
I.5	Products
I.6	Merchandise
I.7	Communication
I.8	Services
I.9	Transports

O.	Output
O.1	Products
O.2	Energy
O.3	Waste water
O.4	Vitiated air
O.5	Solid waste
O.6	Merchandise
O.7	Communication
O.8	Services
O.9	Noise

L.	Stock
L.1	Raw materials
L.2	Energy
L.3	Water
L.4	Products
L.5	Merchandise
L.6	Communication

B.	Inventory
B.1	Land areas
B.2	Structures
B.3	Plant and equipment
B.4	Vehicle fleet

The four main categories input, output, stock and inventory are divided into sub-categories in order to record the material and energy flows as exactly as possible. All data is recorded in a common weight unit (e.g. kg or t). Most of the data necessary normally already exists in conventional company information systems, as for example in the information system of the purchasing department or in the cost accounting system. As material and energy flows are considered as cost drivers there, the consumption is given in monetary values, so that consumption expressed in weight units has to be derived from this data. However, practical

experience has proved that not all data necessary can be generated from existing data. Especially inventory data is not available, meaning that it has to be measured or calculated.

The company input/output balance sheet lists all material and energy flows entering or leaving the company. This information can be used for internal and external communication or the participation in EMAS that demands the recording of environmental data at a company level. It gives an overview of the actual company situation and it is suitable to set up environmental management targets as well as cost targets. It is possible, for example, to set up objectives of reduction of the company induced material flows, which can be controlled by a regular input/output analysis of the company. Furthermore it is possible to link material flow data with economic indicators allowing the company's resource productivity to be determined.

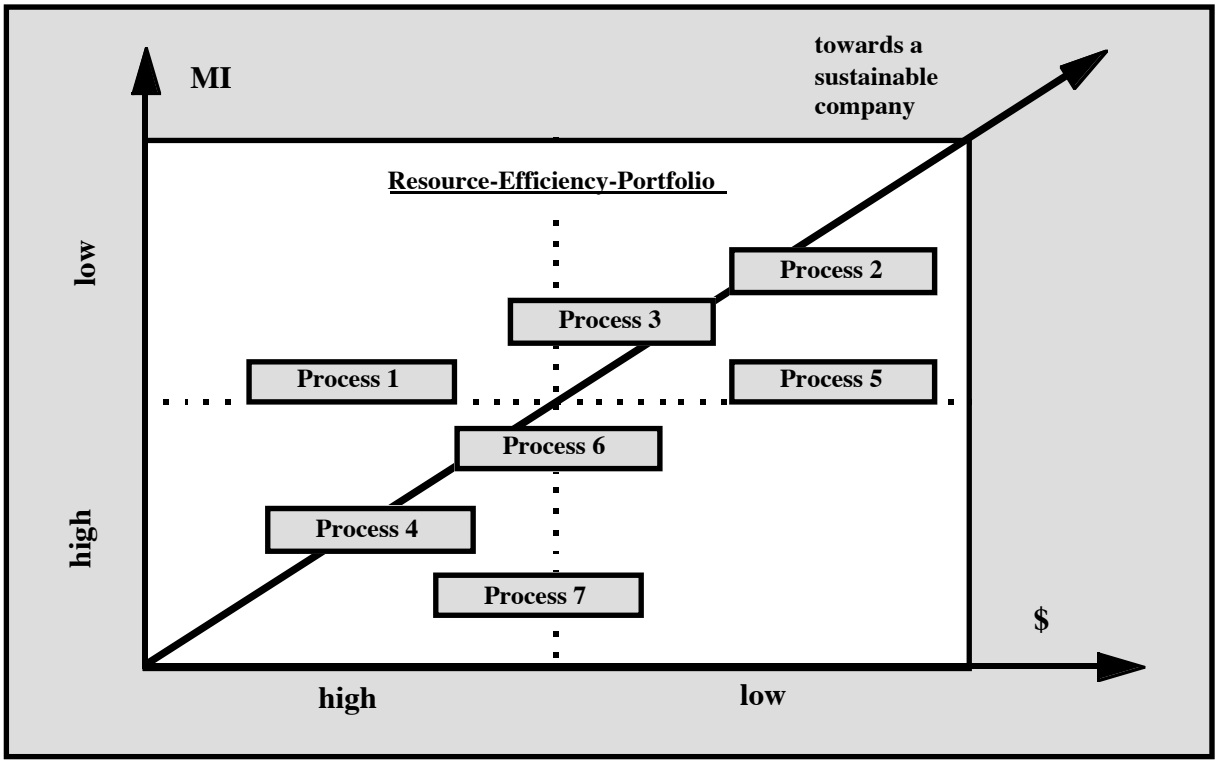
With the aid of a regular input/output analysis, the success of the company's environmental protection efforts can be shown and proved by transparent and reproducible indicators. The long-term objective should be to record environmental data continuously and to treat it by a powerful information system in order to regularly update the company input/output analysis. The input/output analysis can also be used for the comparison of different products, companies or branches, as it is presently discussed with regard to the modification of EMAS.

3.3 Use at Process Level: the Process Analysis

In a second step, company-wide material and energy flows are assigned to the production processes in order to reveal where material and energy are consumed. For this purpose, the company's activities are modelled into a flow-diagram which may be based on existing material flow diagrams. It represents the production processes with their mutual dependencies. For each process, an input/output balance is set up which contains internal inputs from upstream company processes, external inputs from outside the company, internal outputs into downstream company processes (main products of the process) and external outputs (by-products, emissions and waste).

To avoid double-counting, the material intensity of a process is calculated on the basis of external inputs, as internal inputs (coming from company processes) have already been taken into account upstream. In order to allow a life-cycle wide perspective, the external inputs are assessed by their ecological rucksacks. The corresponding economic data is derived from the cost accounting system. The process analysis serves as a screening in order to identify „economic and ecological cost drivers" within a company. The result is the so-called Resource-Efficiency Portfolio at the process level, representing the categories costs ($) and material intensity (MI) for each process (see figure 1). All processes are classified according to their relevance (high and low), where the border between high and low will be defined differently from company to company (e.g. the average of all processes).

Figure 1: Resource-Efficiency-Portfolio at process level, considering costs ($) and material intensity (MI) of processes.



According to the classification of the different processes, specific strategies for action can be derived. The processes classified high/high are very important for the economic and ecological success of the company (the processes 4, 6, and 7 in figure 1). They should be given high priority as the highest reduction potentials can be found here (GOTSCHE 1995). Table 3 indicates possible strategies for action for the different sections of the Resource-Efficiency Portfolio.

Table 3: Strategies for action corresponding to the sections of the Resource-Efficiency Portfolio

	Costs high	Costs low
MI low	Selection of some processes. Review of several cost elements	Low economic and ecological relevance, urgent action not necessity
MI high	High economic and ecological relevance: Should be part of an environmental program, systematic review, exploration of reduction and substitution	Selection of some processes. Review of several inputs

3.4 Use at Product Level: Mass Accounting

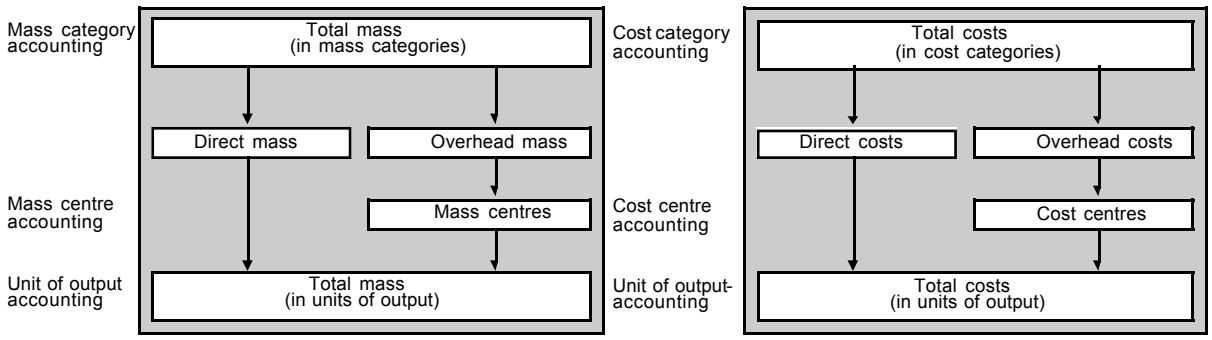
Resource-Efficiency Portfolio at process level aims at generating relevant information for the optimisation of processes. This operational level is common for the technical (or more general operational) personnel, which facilitates implementations of improvements at this level. Nevertheless, a powerful environmental management and eco-management system should

provide information at the product level, too. As the scope at this level is much broader, the whole life-cycle of a product can be considered. So, the REA methodology can serve both process-orientated and product-orientated environmental management.

Economic information at product level can often be taken from the cost accounting system, e.g. in the form of cost price of the produced product or its contribution margin. Detailed ecological information normally does not exist at the product level and has to be derived from the data of the process level with the aid of company mass accounting. There, the material intensity of processes is allocated to the produced products. Mass accounting relies on cost accounting using the similar structure of material inputs and costs.

In the following, a mass accounting procedure will be demonstrated by analogy with absorption costing (see figure 2). But mass accounting can easily be transferred to other cost accounting systems such as direct costing or activity based costing in order to adapt it to the specific needs of companies.

Figure 2: Mass accounting by analogy with absorption costing (PREIMESBERGER, n.y.)



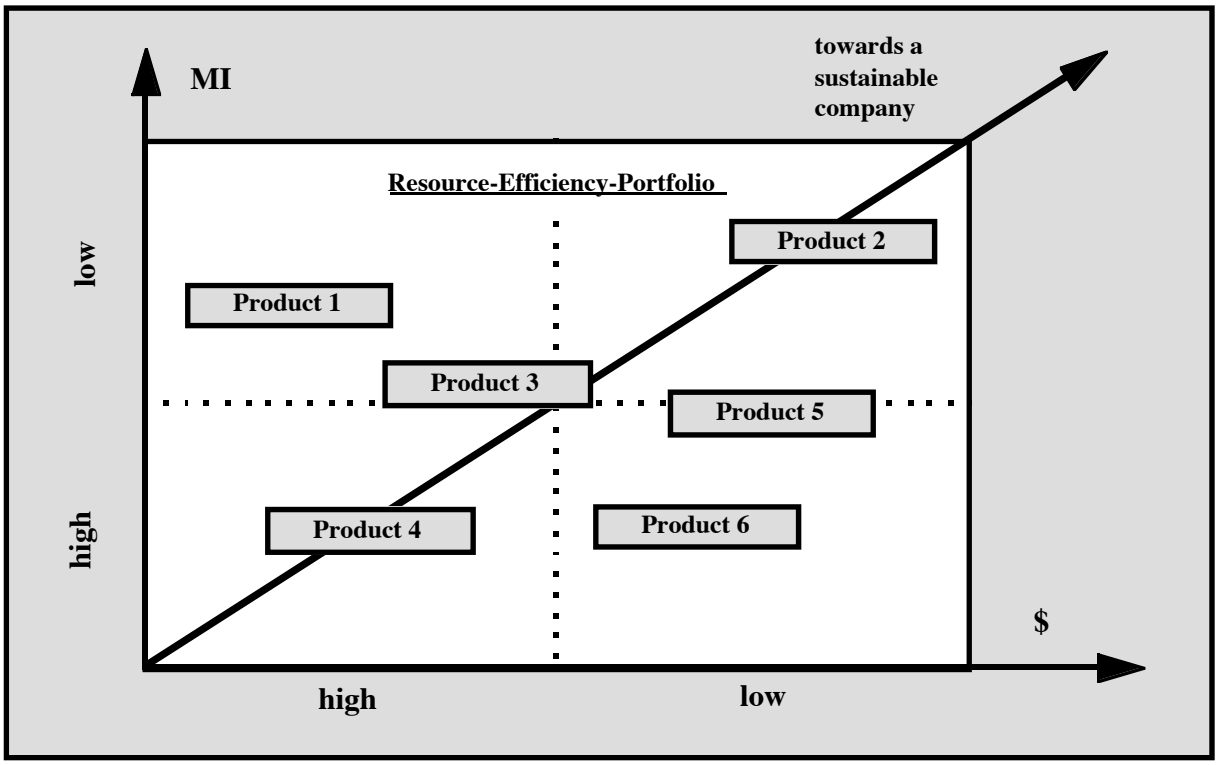
Company mass accounting is subdivided into three steps similar to absorption costing: mass category accounting, mass centre accounting and unit of output accounting as shown in figure 2.

Mass category accounting systematically classifies the company's material and energy flows including their ecological rucksacks. Direct masses can be directly allocated to the unit of output (the produced product) – as for example tyres in car manufacturing – whereas overhead masses are used to produce different units of output. Overhead masses are for example all material inputs of the administration. Overhead masses have to be allocated to the unit of output via mass centre accounting. Mass centres are all company devices (departments, installations, etc.) that are used to produce or sell several products. Overhead masses have to be allocated to the units of output that really caused the mass consumption. During a last step, the unit of output accounting cumulates all material flows with their ecological rucksacks which have incurred until the product leaves the company.

In order to consider the whole life-cycle of a product, the use and the deposit/recycling phase have to be taken into account, too, and it becomes obvious why companies should do so: product use which is less material and energy consuming is becoming more and more a convincing argument to be put to the client. The European Commission, for example, has introduced a classification system, which informs the client about the energy consumption of household goods. Material and cost information for use and disposal/recycling can be obtained

by calculating, measuring, and guessing and should be included into the mass accounting procedure.

Figure 3: Resource-Efficiency-Portfolio at product level, considering costs ($) and material intensity (MI) of products.



The Resource-Efficiency-Portfolio at product level can be used again to develop strategies for action. But unlike the process level where costs and the added value are of main interest, an economic/ecological analysis of products has to consider other economic figures, too, like the contribution margin or profits of products. Thus, in the company's decision-making procedure different Resource-Efficiency-Portfolios will be set up representing various economic figures combined with the corresponding material intensity.

This data becomes input to a Resource-Efficiency Portfolio at product level. Similar to the Portfolio at process level, all products of a company are classified according to their material intensity and their costs in the categories (or other economic figures) high and low in order to explore „economically and ecologically cost driving products“ (see product 4 in figure 3).

It might be useful to distinguish between the production phase and the use-deposit/recycling phase. Products may be classified into:

- production intensive (mono-functional products for one single use such as packing material), producing no or only little impact during use, or
- use intensive, where material and energy consumption during use plays the major role (e.g. washing machines).

Mass accounting which includes use and deposit/recycling enables companies to improve the whole life-cycle of their products including optimisation of material composition and design (SCHMIDT-BLEEK; TISCHNER 1995).

4 Conclusion

Environmental protection and environmental management are increasingly important for companies. This is due to several reasons like increasing costs for environmental protection measures, rising pressure of the markets, anticipation of future changes of economic conditions, legal compliance, and the increasing demand of stakeholders. The concepts of eco-management presented try to link environmental aspects and the economic situation of a company. The existing concepts differ regarding their scope and generate different information.

New findings in environmental science and practical experience have shown that environmental protection can only be efficient if the company's material flows are transparent and well known. This is why material flows are the basis of the concept of Resource-Efficiency Accounting. It represents a first pragmatic step towards the integration of material intensities into the decision-making process of companies. By referring to the inputs, the implementation of REA is quite easy as input data already exists in companies to a considerable extend.

The methodology of REA is flexible enough so that it can be integrated into different cost accounting systems. REA serves both process-orientated and product-orientated environmental management. This is an important feature as a powerful environmental management has to consider information at the operational level and at the product level. The process level is important to detect optimisation potential of the production whereas the consideration of the product level allows a life-cycle-wide perspective. The REA methodology is flexible and decision-making orientated as the Resource-Efficiency-Portfolios can be set up at different company levels and based on different economic indicators. This enables the decision-maker to obtain information according to the intended purposes. Thus, REA can support all decisions with economic and ecological relevance.

It can be stated that a suitable eco-management accounting system will allow the exploration of cost reductions which improve the environmental performance of the company at the same time. It becomes possible to consider simultaneously economic and ecological aspects in order to guarantee a sustainable success to the company.

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Annex

The Authors:

Christa Liedtke is senior fellow of the sustainable enterprise program. She copes mainly with material intensity analyisis, eco-management and resource management. Thomas Orbach is project co-ordinator and deals with eco-management, eco-management accounting and environmental information systems.

The Wuppertal Institute

The Institute was founded in 1991 as a member of the North Rhine-Westphalian Science Centre family of interdisciplinary scientific institutes. It is the first major institute in Germany systematically addressing not only the global ecological challenges but also the complex policy tasks involved in the structural change necessary to meet a sustainable development. The Institute has been conceived as a body that links research, business and public policy. Ernst Ulrich von Weizsäcker, Member of the Club of Rome, was appointed President of the Institute.

Division for Material Flows and Structural Change

The division for „Material Flows and Structural Changes“ of the Wuppertal Institute aims at setting up assessment methods and monitoring tools at all levels of the socio-economic system and at the practical implementation of sustainability strategies and management concepts. The division has four interacting interdisciplinary teams working in the following project areas:

- *„Metabolism of the Economy and Integrated Resource Management“*
  Analysis of environmental strains caused by material flows and material throughput at all socio-economic levels. Development of sustainability indicators and priorities for an increase of eco-efficiency.
- *„Ecological Economics and Ecological Economic Policy“*
  Analysis of economic interdependencies behind empirical data (competitiveness, environment and employment) in order to derive a mix of instruments (from voluntary agreements via product labelling to taxes, reduction of subsidies and tradable permits).
- *„Sustainable Societies“*
  Description of sustainable development for corporate organisation structures. Setting up a mix of indicators displaying past, present and possible future development in combination with economic and ecological framework conditions.
- *„Sustainable Enterprise“*
  Consideration of environmental effects concretely induced by product lines or companies. Specific guidelines for processes, product lines and companies are drawn up, including the development and implementation of corresponding organisational structures (eco-management).

Sustainable Enterprise Program

The „Sustainable Enterprise Program“ in the division for „Material Flows and Structural Change“ attaches top priority to formulating a sustainable company model on the basis of international and national work at macro level, and on the examination and development of economic, ecological and social indicators with respect to their utility for companies in day-to-day business decisions. The team working in the program consists of about 15-20 partly external colleagues with strongly varying scientific backgrounds: natural scientists, economists, engineers, spatial planers, etc.

The team works in close co-operation with client enterprises ranging from small craft companies over small and medium enterprises (SME) to big groups (e.g. hoechst, BMW) - from all economic sectors (construction, chemical products, steel production, manufacturing of metals, etc.). Furthermore, co-operations with trade unions, branch associations and local communities exist.

A multitude of materials and products has been studied within the material intensity analysis concept. The results have been documented in various modules in order to develop a powerful sustainabilitiy assessment tool for companies.

Research Areas of the Sustainable Enterprise Program

Material Analysis with the MIPS-Concept

The MIPS methodology relies of the internationally agreed assumption that life-cycle wide impacts of products can be assessed by their total material input. The material input (including primary materials for energy production, infrastructure, transportation) reflects all the material displaced in nature during the product life-cycle, and can be related to a service provided by the product in question. The total material input of the analysed product minus its actual weight is the so-called "ecological rucksack".
The concept distinguishes the following categories of material inputs:

- abiotic (non-renewable) raw material,
- biotic (renewable) raw material,
- moved soil (in agriculture and forestry),
- water (any volume removed from natural water ways or reservoirs),
- air (if it is chemically or physically transformed).

The MIPS indicator can not only be applied for a life-cycle wide analysis but can also be included in resource management systems, eco-management accounting and auditing schemes in enterprises.

COMPASS - Companies and Sectors on the Path to Sustainability

For companies and sectors it is important to set up quantitative economic, ecological and social targets in order to reach the path to sustainability. Therefore, COMPASS has been developed to provide decision-maker in a company or sector with sufficient information. COMPASS offers the methodological framework, the instruments and measures to operationalise the normative concept of sustainable development at micro level. It gives combined ecological, economic and social information on the status quo and on consequences of decisions. It helps to evaluate the actual company’s impacts and to explore improvement strategies concerning the ecological, economic and social situation of the company.

REA -Resource-Efficiency Accounting

REA links the two dimensions Economy and Environment of the concept of Sustainable Development at micro-level. The ecological assessment of REA is based on the MIPS-concept while the economic dimension of REA may be depicted by various cost accounting systems. REA links the economic and ecological dimension by so-called Resource-Efficiency Portfolios at process, product and company level. There, different economic figures can be shown in relation to ecological ones in order to enable companies to identify "economic and ecological cost drivers".

SMALL - Sustainable Management of Limited Land

The earth is limited with respect to its mass and land. In the research field "land management" an analysis and implementation tool is presently developed that enables the assessment and the management of land use. The analysis tool will focus on a quantitative and qualitative assessment of the land usage for a product or service during its full life-cycle. The implementation tool will focus on sustainable land management that formulates among others concrete opportunities for enterprises to reduce their land use. Further issues are the analysis of existing steering instruments of land utilisation (urban development plans, laws etc.) and the development of possible incentives for a sustainable utilisation of land ("surface tax", licenses etc.).

The Resource Management Program

Resource Management (RM) is a management system designed to increase the resource-efficiency by improving life-cycle wide costs and material flows. RM includes three components: material flow management, product management and eco-design. Material flow management describes the material flow reduction potential of processing technologies during manufacturing, recycling and waste disposal. Product/Service management improves the environmental performance of the products during their use by e.g. sharing concepts. Special emphasis is put on developing new, eco-efficient products and services on the basis of sustainable service concepts.

Projects of the Sustainable Enterprise Program

- *Indicators for Sustainability at Micro Level*
  Developement of a draft set of indicators in close contact with several companies.
- *Sustainable Sector*
  Development of indicators for a „Sustainable Plastics Industry“.
- *MIPS and Resource Management*
  Implementation of Ressource Management into companies, projects with Hoechst, Kambium, and others.
- *Environmental Management and Information Systems*
  Holistic ecological, economic and sozial options how to design and produce textiles in a sustainable way in co-operation with „Hess Natur“.
- *Human Resource Mangement*
  Formulation of social targets, conflict and communication management in co-operation with 7 SME.

- *Eco-efficient services*
  Drawing up concepts of sustainable product-service mixes in the area of construction and housing.
- *The MIPS-House*
  Development of a „Low-Resource-House“
- *Sustainablility and Biotics*
  Development of indicators expressing the impact of land use, methods of accounting and land management strategies.